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OPERATIONS IMPROVEMENT PROGRAM

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PREPARED BY:

Federal Aviation Administration
San Francisco International Airport Staff
Air Transportation Association

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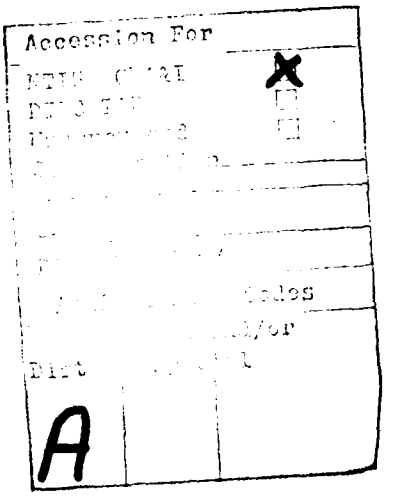

PREFACE

This study of air traffic delay at San Francisco International Airport, its causes, and potential solutions, has identified a comprehensive program of delay reduction measures which, if implemented, has the potential to dramatically reduce the level in cost of delay. The potential cost savings outlined ~~are not~~ intended to represent absolutes but rather to point out the most productive directions in which to focus industry action.

The study was conducted from 1976 through 1980 by a Task Force Composed of Representatives of the Federal Aviation Administration, the airlines serving San Francisco and San Francisco International Airport Staff. The FAA provided the support of the Washington Technical Organization and consultant support from Peat, Marwick, Mitchell & Co. (PMM).

The study considered in detail 26 recommendations for improvement of operations at San Francisco International Airport. Seven of these recommendations are currently being implemented. Six were dropped from present consideration and 13 are still recommended for implementation. Task Force members will continue to meet as necessary to assist in the implementation of these 13 remaining recommendations and to provide a forum for the identification and the assessment of further improvements.

INTRODUCTION:

Background

In recent years runway capacity has steadily declined at the nation's airports. Noise restrictions and wake vortex separation standards, when coupled with increases in aviation demand, have resulted in significant increases in delay and delay-related fuel consumption.

The development of new metropolitan airports to augment system capacity and reduce delay is difficult and costly, as is the incremental expansion of existing facilities. It has become clear to continue satisfactory air transportation service, the aviation industry must concentrate on achieving the highest efficiency of the existing airport system. To accomplish this and to identify future requirements in practical terms, quantitative performance data for major airports are needed. Such data would permit wise management and decisions on (1) optimum airport use strategies; (2) expenditures for runways and other facilities and equipment; (3) research and development priorities.

The establishment of a local task force was an outgrowth of Federal Aviation Administration (FAA) and Air Transport Association (ATA) concern about capacity and delay at the nation's major airports. A 1974 FAA report on airport capacity furnished considerable insight to capacity-related operational problems at 8 of the Countries major airports; however, it was decided that the findings should be evaluated by the persons directly involved in the operation and use of the airports. Therefore, in late 1974, the FAA established an ad hoc working group with the primary purpose of developing an action plan to reduce airport delays and to identify development options for implementation for further study at 10 major airports.

It was anticipated that recommendations developed jointly would form a basis of support for individual management decisions by each participating group. The net result of these joint recommendations was envisioned to be a coordinated series of further actions whose combined affect would be to reduce delays substantially. Aircraft delays at San Francisco International Airport have grown significantly over the past few years (12,267 hours in 1977). The task force formed to study congestion and delay at San Francisco included representatives of the Airport Management, the Federal Aviation Administration, Air Carriers and the Air Transport Association.

Not only will the reduction of delays improve the aircraft operating cost and equipment utilization, it will reduce fuel consumption which is an important national goal. The estimated fuel savings is 500 gallons per hour for taxi delay or 1,000 gallons per hour while holding in the air.

A Joint Land Use Study for the San Francisco International Airport Environs Area is in the final report stage. The study recommended actions to resolve problems of incompatibility (mainly aircraft noise in residental areas) between the airport and the surrounding communities. The San Francisco Land Use Study did not recommend on-airport development programs such as those contained in this report.

The objectives, scope and methodology of the task force study are summerized in the following.

OBJECTIVES:

Considering San Francisco International Airport's escalating delays and their cost implications, the task force agreed on four objectives to guide the analysis of current and future operations period. These objectives were:

1. To estimate levels of airport capacity and aircraft delay and to identify causes of delays associated with operations in the terminal airspace, airfield, and apron-gate systems.

2. To estimate the potential benefits of reducing aircraft delay through alternative air traffic control procedures, airport use policies, facility developments, and FAA NAVAID programs.

3. To estimate current and future relationships between air traffic demand and aircraft delay as an aid for future planning.

4. To determine airport ground side and access growth capabilities and identify areas of potential airport capacity constraints.

SCOPE:

The analysis in this study focused on means of increasing the operating efficiency of the airport and reducing aircraft delay through changes in air traffic control procedures, changes in airport use policies, and (to a limited degree) potential airport development actions.

Environmental concerns were recognized in developing recommendations, but were not within the scope of the task force study and are not addressed in this report.

METHODOLOGY:

This study was conducted using a simulation model that reflects observed system operations. After the model was validated against real-world data on demand and delay, it was used to quantify the benefits of the delay reduction options identified by the Task Force. The data from experiments modeling proposed improvements were compared with data from base line experiments, and the potential reduction in delays were assessed. Capacity gains and delay reductions for the various alternatives are available in technical reports prepared by PMM.

RECOMMENDED IMPROVEMENTS:

The task force reviewed potential improvements in two areas:

1. Air traffic procedures
2. Airfield improvements

The review of these potential improvements - including the qualification of benefits, operational aspects, etc. - resulted in closer consideration of 26 specific recommended improvements. Brief descriptions of the improvements and estimates of their potential annual savings are shown in tables 1, 2 and 3. Details on the individual recommended improvements are given in Appendix 1.

TABLE 1 - RECOMMENDED IMPROVEMENTS:

No.	Improvement	Potential Annual Savings	
		1979 Dollars	Gallons
1	Extend Txy L to Rwy 19L	$ 420,000	175,000
2	Extend Txy K to Txy C	18,000	7,500
3	Extend Rwy 19R to 8500'	720,000	300,000
4	Install Centerline Lights Rwy 1R/19L	480,000	200,000
5	Improve Blast Fence Rwy 1R	36,000	15,000
6	Expand Visual Approach Procedure	2,600,000	2,200,000
7	Fog Covering Portions of Airport	N/A	N/A
8	Establish a Common Runup Area	N/A	N/A
9	Establish a Standard Ground Guidance System	N/A	N/A
10	Provide a Convenient Commuter Aircraft Facility	N/A	N/A
11	Install Anemometers Runways 10 and 19	90,000	55,000
12	Increase Fillet Size Exit Txys D and U	8,000	5,000
13	Provide Remote Control Runway X's With High Intensity Rwy Lights	180,000	75,000

NOTE
N/A not available
Improvements 3, 5, 8, and 11, may provide significant noise relief.
Improvements not listed in order of priority.

TABLE 2 - IMPROVEMENTS BEING IMPLEMENTED

No.	Improvement
14	Extend Taxiways A & B to Runways 10L and 10R
15	Retain ILS Runway 28L
16	Install 3-Bar VASI Runway 1R
17	Install 3-Bar VASI Runway 19R
18	Install DME's at Localizers Runways 28 and 19
19	Install Taxiway Centerline Lighting
20	Install ILS Runway 10R

TABLE 3 - PROPOSED IMPROVEMENTS DROPPED FROM PRESENT CONSIDERATION

No.	Improvement
21	Extend Taxiway V to Taxiway L
22	Extend Taxiway M to Taxiway L
23	Procedures to Allow Simultaneous Departures From Runways 10R and 10L
24	Expand Runup area Runway 1R
25	Construct Helipad
26	Establish STOL Runway

APPENDIX 1

RECOMMENDED IMPROVEMENTS

ITEM 1

Extend Taxiway L to Runway 19L

Problem

Runway 19L is 9500 feet in length while runway 19R is only 7000 feet long. Each year SFIA experiences severe storm conditions requiring take-offs on Runway 19L with no other option. Landings are on Runways 19R and 19L. The only taxiway access to Runway 19L crosses that runway in front of the glideslope antenna requiring departing aircraft to wait if arrivals are within 5 miles. Annual delays will average about 350 hours.

Background

Some 10 years ago an analysis was made of taxiway improvements which would complete independent access to all runways. The extension of Taxiway L from Taxiway C to the North end of Runway 19L was considered but rejected since the condition requiring its use occurred only 0.4% of the year which was felt to not be significant.

Study Results

The conditions under this study were factually recorded and were not significantly different from previously used data. However, this study was able through a computer prediction program to establish a delay factor for departing aircraft under IFR conditions. From this it was determined 700 annual operations were delayed an average of 30 minutes or the equivelent of 350 hours.

Improvement Project

The extension of Taxiway L from Taxiway C to the North end of Runway 19L would allow aircraft to cross the runway to an independent parallel taxiway clear of adverse effect on the ILS glideslope. Several taxiways connect the terminal area with Taxiway L and allow aircraft to move across the Runways with minimal delay.

Cost/Benefit Analysis

The analysis showed a reduction of 350 hours of delay annually which (based on a $1200 per hour aircraft operating cost) would provide a saving of $420,000 each year to the airlines. The project cost is estimated to be $1,650,000 which makes this project cost effective in less than 4 years. Annual fuel savings would be approximately 175,000 gallons.

Conclusion

Based upon the study, genuine need for the extension of taxiway L has been established and justification is sufficient for an ADAP project.

ITEM 2

Extend Taxiway K to Taxiway C

Problem Generally under a condition of Southeast winds Runways 19L and 19R are used for landing and Runways 10R and 10L are used for all taleoffs. Taxiway access to the takeoff threasnolds of 10R and 10L impinges on the use of those runways even under a single flow configuration. Independent taxi flow permits greater flexibility for sequencing departure and is necessary for simultaneous departures.

Background The strong Southeast wind condition occurs only about 6% of the time but does limit departures to a single stream. Under present conditions aircraft taxiing to Runway 10L must pass through Runway 10R and its runup area eliminating the flexibility in assigning departures. The extension of Taxiway K across Runway 10L to Taxiway C would provide an additional crossing to feed Runway 10L with Taxiway C. It would primarily help aircraft from the North Terminal so tney would not be routing traffic an additional 900 feet to taxiway D.

Study Results It is assumed that extension of Taxiway K across to Taxiway C would provide a reduction in delays of 25% to aircraft departing Runways 10R and 10L by approxi mately 20 seconds.

Improvement Project The extension of Taxiway K to Taxiway C will require approximately 1000 lineal feet of new taxiway. This taxiway will parallel Taxiway D which is located about 900 feet East. It will allow a more direct routing from the North Terminal to Taxiway C. It also would add an exit taxiway from runway 28R directly to the North Terminal.

Cost/Benefit Analysis In this case only the improvement gained by greater flexibility for sequencing departures is credited. The value related to arrivals was undetermined but felt to be rather small. The technical analysis shows only $13,000 per year savings for 15 hours delay while the project cost is estimated to be $825,000. The projcet would also save approximately 7,500 gallons of fuel annually.

Conclusion This project is an alternative to the extension of Taxiways A and B to the ends of Runways 10R/L whicn is an on going project under ADAP. However, there is positive ATC flexibility attained and it would significantly relieve congestion near the North Terminal.

Item 3

Extend Runway 19R to 8500

Problem Runway IL and 19R is the shortest runway on the Airport and has a useable length for takeoff or landing of 7,000' Many aircraft can not use this runway due to its length, and lack of instrumentation.

Background This problem has existed for a number of years. When Runway 1R and 1L are used for departures, the short length of Runway IL dictates it being used for relative light/ short segment flights. This condition contributes to Runway 1R rapidly becoming departure saturated. During periods of arrivals to Runways 19R and 19L; the "staggered" landing thresholds, lack of precision navigational guidance to 19R, and its 7,000' length results in a high percentage of refusals to use this runway. These refusals are based on aircraft category, performance requirements, weather and pilot preference for the longer Runway 19L.

Study Results The consultant's (PMM) analysis of this item, providing an additional length of 1500' (for a total length of 8,500') combined with the 3-bar VASI on 19R indicated a possible reduction in arrival delays in the order of 50% during peak hour demands while in the "southeast configuration."

Improvement Project The originally much discussed recommendation was for a 650' extension northward into the Bay (which would provide true common thresholds for Runways 19R and 19L) and a south extension of 850'. This concept, it was recognized, would involve extensive environmental constraints on the northward extension, and physical constraints for the southward extension.

In attempting to evaluate any and all enhancement of this runway complex, two other concepts were considered worthy of future exploration:

A. Extend Runway 19R only to the north for the 650' previously discussed, which would provide a commonality of a runway threshold, and a total length of 7,650'.
B. Extend runway 19R 1,000' north which would provide for a length of 8,000' and to provide for the desired commonality of thresholds, extend Runway 19L 350 feet north which would provide a total length of 9,850'.

The aforementioned environmental constraints would be applicable to both of these concepts, however there would be no requirement for analysis of the south end physical restraints.

Cost/Benefit Analysis

Cost benefit figures are available only for a runway length of 8,500' with extensions at both runway ends. The estimated cost is 3 to 5 million dollars based on 5% annual use of Runways 19R and 19L and 67% for Runways 1R and 'L combined with increased ATC flexibility, delay savings of $720,000 per year would be realized. The project also save approximately 300,000 gallons of fuel annually.

The comparable benefits to be gained by either items "A" or "B" under the improvement project are not known at this time.

Conclusion

This study's Interim Report published in August of 1978 listed the expansion of Roadway 19R to 8,500' to be one of the three most significant projects to reduce delays. Even with enviromental and funding uncertainties, this development item still remains a high priority.

ITEM 4

Install Centerline Lights on Runway 1R and 19L

Problem

During a 4-hour period that occurs 30 days during the year the visability minumums at San Francisco International Airport range between 1600' RVR and 700' RVR. During this condition approximately 1/2 of the departing aircraft are delayed 20 additional minutes. The annual delays are about 400 aircraft hours.

Background

Runways 28R and 28L have Bi-Directional Centerline Lights. Aircraft can depart these runways with 700' RVR minimums. Since the fog moves in from the West a condition frequently exists where the West end of Runways 28R and 28L are below 700' RVR while Runway 1R is at or above 700' RVR Departure minimums for Runway 1R could be reduced to 700' RVR with the addition of runway centerline lights. Bi-Directional runway centerline lights may not reduce minimums for ILS Runway 19L landings or departures but would improve runway visibility during IFR operations.

Study Results

An analysis by PMM indicated a reduction of 400 annual hours of delay with the installation of centerline lights on Runway 1R.

Improvement Project

The establishment of runway centerline lights on Runways 1R and 19L would substantially reduce delays and improve safety with increased runway visibility during IFR weather conditions.

Cost/Benefit Analysis

The estimated cost for this installation will be $500,000. The reduced delay would be 400 annual aircraft hours at $1200 per hour or $480,000 per year. This annual savings is almost equal to the cost of development. This project would also save an estimated 200,000 gallons of fuel annually.

Conclusion — Providing centerline lights for Runways 1R and 19L is economically justified and it would increase the factor of safety for aircraft using these runways.

ITEM 5

Improve Blast Fence on Runway 1R

Problem — Departing aircraft on Runway 1R may not apply takeoff thrust until they pass a point 600' from the runway end.

Background — The existing 8' blast fence at the approach end of Runway 1R provides inadequate protection for vehicles passing along the Bayshore Freeway. As a result of this hazard, the Airport Sponsor has restricted aircraft from applying full power until reaching a point 600' north of the blast fence. This 600' is effectively lost to departures. The added length available for Runway 1R would reduce the number of aircraft required to use Runway 28. This would affect three (3) aircraft per day over 67% of the year when arrivals use Runway 28 and departures use Runway 1.

Study Results — Taxi time savings of about 2 minutes and delay savings of about 30 seconds per aircraft would be realized. Total annual delay savings would be thirty aircraft hours at $1,200 per hour or $36,000 per year. A more important result could be the mitigation of aircraft noise.

Improvement Project — If the blast fence could be improved on Runway 1R to prevent jet blast from reaching the Bayshore Freeway 600' of runway could be recaptured resulting in more aircraft being able to use Runway 1R for departures.

Cost/Benefit Analysis — The cost of a new 14' blast fence is estimated at $500,000, The annual savings in delay costs are about $36,000 per year. Annual fuel savings would be approximately 15,000 gallons annually.

Conclusion — A new blast fence serving Runway 1R would not be economically justified unless it could also provide some noise relief.

ITEM 6

Expand Visual Approach Procedure

Problem

The minimums extablished to permit a controller to vector aircraft for a VISUAL approach are dependent on the weather observation taken at the airport. The ceiling at San Francisco must be at least 2100 feet. This ceiling is determined by adding 500 feet to the minimum vectoring altitude of 1600 feet. (ATC Handbook 7110.65, paragraph 796 a.)

Any time the ceiling is below 2100 feet, (regardless of the weather conditions away from the field) aircraft must be in a single file for their approach to the airport.

Background

On a significant number of days during the summer STRATUS period, ceilings over the airport are frequently below 2100 feet, however, conditions on the approach are clear skies and unlimited visibility.

The strict weather requirements in ATC Handbook 7110.65 specifying when aircraft can be vectored for a visual approach prevent controllers from assigning simultaneous approaches to arrivals to runways 28. During the conditions described, delays are unavoidable because aircraft must hold for their turn to make a full instrument approach in VFR conditions.

Study Results

When visual approaches and simultaneous landings are possible, the airport capacity is established as 82 operations per hour. However, when single file apporaches are necessary because of ceiling conditions reported over the airport, the capacity is reduced to 69 operations an hour.

Improvement Project

The procedure in Handbook 7110.65 assumes that the weather conditions reported at an airport prevail tnroughout the local area. The procedure should be expanded to take into account the conditions observed or reported on the approach to the airport.

Cost/Benefit Analysis

It is estimated this change would reduce delays approximately 30 minutes to arriving aircraft by permitting simultaneous approaches to Runways 28R and 28L when ceilings drop below 2100 feet.

During the summer months, STRATUS weather affects about 10% of the daily operations approximately 2 hours each day for approximately 45 days. Total delay savings are

estimated as high as 2,200 aircraft hours which totals $2,600,,000.00 each year at $1,200.00 per aircraft hour Fuel savings would be approximately 2,200,000 gallons annually.

Conclusion — This improvement item offers substantial delay savings to the user. It could be implemented by expanding Handbook 7110.65 requirements to permit vectoring of an aircraft for visual approaches under expanded weather criteria requirements peculiar to an individual airport.

ITEM 7

Fog Covering Portions of Airport

Problem — Local fog conditons existing only for a short distance and of low ceiling often obscure certain portions of the airport. Due to tne location of the airport approach zones to the prime runways, there are cases wherein only the final approach segment is obscured, yet other approaches to runways not normally used are well above operational visibility requirments. The basic problem is that there are no immediate change procedures which would allow aircraft having to abort their approach to a runway being utilized in the current traffic flow and yet complete an approach and landing to another runway in visual or "contact" wather conditons. The problem is furtner mired in the decision making process which would have to take place on very short notice eitner by tne pilot or controller (or both), and the mechanics of otner traffic involved. The bottom line of the problem very simply is that there are numerous diversions and missed approaches to runways in use due to this "bayside" type fog, while entire portions of the airfield are in tne clear.

Background — The problems as described in the previous paragraph have existed for as long as there has been a requirement for schedule Air Carrier service to SFO.

Study Results — Computer generated delay analysis of this item was not accomplished. The listed problem and background data obtained from local staff (airline and ATC) who are on site and have witnessed and experienced this type of situation.

Improvement Project — Weathe r criteria and aircraft performance requirements, coupled with airline operating parameters should be explored and evaluated to develop "Contact" type approach envelope which would be compatible with ATC system and controller responsibilities.

Cost/Benefit Analysis — It is difficutl to assess total overall cost benefits to be accrued, however a base figure of $5,000 savings can be established for every diversionary operation not required.

Conclusion — This item is recommended for further consideration.

ITEM 8

Establish a Common Runup Area

Problem — Aircraft requiring runup most often utilize the north end of the airport immediately adjacent to the approach ends of Runway 19L and 19R the east end of the airport adjacent to the approach ends of Runways 28R and 28L. Traffic moving to and from these areas often has to cross active runways and taxiways creating both work load and space problems. These aircraft often perform runups in the area immediately adjacent to the active departure and arrival runways with the potential hazard of another obstruction. Delays may be encountered moving the traffic to and from these areas on a regular basis.

Background — Soon after the advent of jet aircraft, ground runup facilities within airline maintenance property were phased out. The old facilities were not constructed to withstand jet blast and the maintenance bases were too close to populated areas to accept high noise emissions from runups. Infrequent use of a very low use taxiway for runups was acceptable since it was the furtherest point from residence as allow aircraft to project noise and blast over the Bay.

Study Results — No study analysis was made of delays related to interference of runups with ongoing flight operations.

Improvement Project — The time and expense of moving aircraft to a common remote area is not reduced by seeking another common runup area. However, a common runup constructed by an airline consortium could be developed on the North side of the Airport complete with blast protectors and noise suppressors.

Cost/Benefit Analysis — The study made no evaluation of cost in delay time and the project would be an airline improvement which could vary in cost tremendously, dependent upon the degree of noise suppression used. Therfore, no comparison is possible.

Conclusion — The feeling that the use of the taxiway for runups causes an inconvenience and possible operational delays is pretty well agreed upon. The greatest advantage to an off taxiway location is the reduction of certain operation hazards and the relocation offers an opportunity to reduce airport noise. It is recommended that a thorough project study be initiated.

ITEM 9

Establish a Standard Ground Guidance System

Problem

Although there are existing standards for runway markings, guidance signs, and lighting systems, many in-use systems at major airports were commissioned/installed prior to adoption of some standards, or have not been modified to said standards. Gate position markings and associated lead-in guidance are not standard, and in some locations positive identification of specific gate areas does not occur unitl the aircraft is in very close proximity. Flight crews are faced on a regular basis with having to cope with a variety of airfield/taxiway/runway identifications, and this lack of standardization can in some instances dealy or slow traffic flows through congested ground areas.

Improvement Project

Since it can be assumed that although San Francisco Internaitonal has been in a constant program of updating all airport ground guidance systems, there is still a need for Naitonal/International Standards to be agreed on. This would encompass input and endorsement from all involved entities, Airport Managements, Airlines (and other concerned airport tenants), Pilot Groups, etc. and it is realized that this Airport Improvement Task Group is limited in what it can propose on the matter. However, the consensus remains that such an effort should produce a commonly used, flexible ground guidance environment and as such would smooth the flow of all ground traffic in addition to reducing bvoth pilot and controller workload.

No attempt was made to evaluate tne cost/benefit aspect of this item.

ITEM 10

Provide a Convenient Commuter Aircraft Facility

Problem

The commuter operation is mixed with airline operations and are frequently held up by grould activity at adjacent gates. The Airport has not established a consistant operating procedure and have depended on Airlines to handle commuters as long as thier schedules fit. As a result, the commuter locations change freguently. There is always a danger when relatively lignt aircraft must move in the same area as the large jets and high blast forces.

Background

Commuter Airlines have been gypsy in nature serving for short periods wherever they could operate at an airline facility. In the past year, as a result of deregulation, this has become a significant part of air transportation. Now an operational area is needed permanently in the terminal area to consolidate the activity of Third level carriers.

Study Results

The study was unable to quantify the effects of a commuter flight operation on Airport capacity or operational delays since no single area is large enough for a consolodated facility and therefore no site was selected. The replacement of service which used airline jet transports with smaller propeller aircraft will effect the airport capacity slightly in operations but significantly in reduction of passenger seats.

Inprovement Project

The best operation for third level commuters would be close to the intersection of runways which would make for minimum taxing and approach time. It would also place interline passengers near the middle of passenger terminals. A dedicated gate capable of handling up to 3 DH-7 aircraft is needed on the new pier D. scheduled for construction during the next 2 years.

Cost/Benefit Analysis

The study was unable to evaluate the cost since there were no plans to estimate nor was there an alternative to compare.

Conclusion

The present Airport plan for third level commuters is to consolidate terminal activity in the new North Terminal using two areas adjacent and one remote for aircraft parking. This plan should be followed while the other two terminals are reconstructed in the modernization program. Access for ground level loading should be built in to the new Centeral Terminal pier to allow for eitner relocated or new third level commuter operations.

ITEM 11

Install Anemometers for Runways 10 and 19

Problem

Wind direction and veloctiy for all runways is derived from equipment located between Runways 28R and 28L the east end of the field. Wind on the other runways is somtimes reported pilots as quite different from the wind being read by the controller.

Background

San Francisco Airport is laid out with two sets of paralled runways. It is operationally advantageous to use a runway configuration which utilizes all four runways at the same time. On a Runway 28/01 configuration for example, one set of parallels is used for landings and the other set is used for departures. Another configuration is to use Runways 19 for landings and Runways 10 for departures.

Study Results

The percentage of time in which Runways 19 and 10 are partly or solely used each uear is estimated to be approximately 8%. This is based on a survey taken in 1974. It is also estaimated that runway configuration change from a West Plan (use of Runways 28 and 01) to a southeast plan (use of Runways 19 & 10) occurs approximately 20 to 30 times each year. For each of the configuration changes, 5 to 10 aircraft incur a delay taxing from one runway to another. Delays to aircraft could be reducted approximately 15 minutes each.

Improvement Project

ATC would be able to determine sooner with more accuracy the necessity to make a runway change. This would be able to make a runway change. This would help prevent aircraft from being delayed because of a runway assignment to an unacceptable runway.

Cost/Benefit Analysis

This item was not quantified by the consulting firm, however, using available traffic figures obtained from surveys and estimating occurance of runways configuration changes, delays would be reduced by 15 minutes to each of approximately 200 to 300 aircraft each year. This is about 50 to 75 aircraft hours and at $1200.00 per hour, amounts to $60,000.00 to $90,000.00 savings. The cost of installing anemometers on two runways is approximately $20,000.00. Annual fuel savings would be approximately 55,000 gallons.

Conclusion

Although much of the information used to arrive at the Cost/ Benefit Analysis is estimated, it is considered to be conservative and reasonable. In addition, the task also serve to enhance noise abatement procedures.

ITEM 12

Increase Fillet Size Taxiways D and U

Problem

Landing aircraft rolling out on Runway 28R at SFO destined to the north side of the airport (maintenance nangars, air freitht, etc.) have to come to almost a complete stop prior to exiting Runway 28R at Taxiways D and U because these exits are not of the high-speed filleted variety which permit aircraft to clear the runway rapidly. The problem becomes more acute with the advent of more large/wide bodied aircraft who are unable to exit the active runway quickly and become contributors to increased ATC spacing and resultant delay.

Background

Until recent years due to the majority of the airport activity being confined to the existing terminal areas, there has been no dire need for improved access to the north side taxiways, runway exits and associated north side operations. However, with the increase in air carrier operations, with emphasis on the maintenance and air freight operations on the north side, the problem of "clearing" the runways as expeditiously as possible after landing roll-out has become as important in many was as the same type of requirement on the passenger terminal side of the airport.

Study Results

Improved fillets on taxiways will save an estimated ten seconds for each aircraft destined north side off Runway 28R and will also probably salvage 20 plus missed approaches per year. (Missed approaches by aircraft following aircraft which have landed and not cleared the runway in the vicinity of Taxiways D and U).

Improvement Project

Priority #1 - Fillet Taxiway U to Taxiway C estimated cost $260,000.00

Priority #2 - Fillet Taxiway D to Taixway C estimated cost $400,000.00.

Cost/Benefit Analysis — Peat, Marwick, Micthell and Co.'s analysis of this item with suggested hi-speed fillets indicated a potential savings of $8,400.00 per year based on file data as to number of aircraft requiring these exits and possible missed approaches by other aircraft due to the inability of preceeding landing aircraft to exit the runway rapidly enough. Annual fuel savings will be approximately 500 gallons.

Conslusion — This development will provide a faster exis from the runway and reduce runway occupancy time.

ITEM 13

Provide a Remote Controlled Runway "X"

With High Intensity In-Runway Lights

Problem — The Airport was built on filled land which lays upon varying depths of mud causing irregular subsidence of runways and taxiways. A high degree of maintenance is required which causes runways to be shut down freguently.

Background — The process of shutting down a runway and reopening includes laying out large panels for the "X" markers on each end of the runway. Light weight cloth panels will not hold up under frequent use nor will they stay in place under the normal wind conditions. Heavy panels are slow to install and remove which costs some delay to aircraft wishing to use the runway following repairs or construction.

Study Results — Approximately 130 runway closures occur each year and approximately 100 minutes additional time is required to remove the panels after work is completed. Aircraft delays amount to about 150 hours a year.

Improvement Project — A proposed permanent installation of high intensity lights in the form of an "X" would be made at the ends of all runways and be activated by the tower. This is a non-standard installation which may be acceptable as an aid to the traffic controllers.

Cost/Benefit Analysis — The total delay is 150 aircraft hours with a total delay value of $180,000 per year. The estimated cost is $1.5 million. Annual fuel savings would be approximately 75,000 gallons.

Conclusion — The problem seems to relate to criteria under Federal Air Reguations which would require a permanent visual cross to be used on the Airport with 24-hour Air Traffic Control. We recommend this project for further FAA R & D investigation.

APPENDIX 2

IMPROVEMENTS BEING IMPLEMENTED

ITEM 14

Extend Taxiways A and B to Runways 10R and 10L

This item was funded under ADAP Project No. 08 in 1977. Is is scheduled for sonctruction during the spring and summer of 1981.

ITEM 15

Retain Runway 28L ILS

A decision has been made to retain this Catagory 1 ILS.

ITEM 16

Install a 3-Bar VASI for Runway 1R

This item is currently being considered by FAA as a future project. Rising terrain in this approach makes siting a VASI difficult.

ITEM 17

Install a 3-Bar VASI for Runway 19R

This is an approved project scheduled for installation during FY 80.

ITEM 18

Install DME's at Localizers Serving Runways 28 and 19

Installiation of these DME's began in May 1980. Consideration was given to locating the DME's at the glide slope units. After careful evaluation this option proved to be undesirable.

ITEM 19

Install Taxiway Centerline Lighting

This item for 31,000 lineal feet of taxiway centerline lights was funded under ADAP Project No. 10 in 1979. This project is in the design State.

ITEM 20

Install ILS Runway 10R

This item is an approved project scheduled for completion in February 1983.

APPENDIX 3

PROPOSED IMPROVEMENTS DROPPED FROM PRESENT CONSIDERATION

ITEM 21

Extend Taxiway V To Taxiway L

This project would provide many of the benefits associated with the proposed extension of taxiway L from Taxiway C to Runway 19L. Is was concluded that the extension of Taxiway L provided more flexibility and delay reduction than would the extension of Taxiway V at approximately the same cost. The extension of Taxiway L nad the additional advantage of not requiring runway closure during construction.

ITEM 22

Extend Taxiway M to Taxiway L

A careful evaluation of this item revealed that it would not increase operational flexability.

ITEM 23

Procedures to Allow Simultaneous Departures From Runway 10R & 10L

The SF Control Tower and Bay TRACON will continue to work towards impoementation of this procedure. It is an FAA internal procedure that needs to be evaluated. The operational benefits of ths option may be more than offset by problems caused through increased residential noise exposure.

ITEM 24

Expand Runup Area for Runway 1R

After careful consideration this item was dropped. No appreciable operational benefit could be identified.

ITEM 25

Construct Helipad

No scheduled helicopter service exists or is planned for SFIA. This item was, tnerefore, dropped from futher consideration.

ITEM 26

Extablish A STOL Runway

Operational advantages to STOL aircraft would be offset by reduced flexability and increased delays to conventional aircraft. Therefore, tnis item was dropped.